COMPARATIVE EVALUATION OF THE FRACTURE RESISTANCE AND FRACTURE PATTERNS OF ENDODONTICALLY TREATED ANTERIOR TEETH RESTORED WITH TWO DIFFERENT ESTHETIC POSTS –AN IN VITRO STUDY

Dissertation Submitted to

THE TAMILNADU DR. M.G.R. MEDICAL UNIVERSITY

In partial fulfillment for the Degree of

MASTER OF DENTAL SURGERY

BRANCH I

PROSTHODONTICS AND CROWN & BRIDGE

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CERTIFICATE

This is to certify that the dissertation titled **"COMPARATIVE EVALUATION OF THE FRACTURE RESISTANCE AND FRACTURE PATTERNS OF ENDODONTICALLY TREATED ANTERIOR TEETH RESTORED WITH TWO DIFFERENT ESTHETIC POSTS –AN IN VITRO STUDY"** is a bonafide record work done by **Dr.P. Anil Kumar** under our guidance and to our satisfaction during his post graduate study period between 2008 – 2011.

This Dissertation is submitted to **THE TAMILNADU DR. M.G.R. MEDICAL UNIVERSITY**, in partial fulfillment for the Degree of **MASTER OF DENTAL SURGERY – PROSTHODONTICS AND CROWN & BRIDGE, BRANCH I.** It has not been submitted (partial or full) for the award of any other degree or diploma.

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INTRODUCTION

The success of current endodontic procedures has resulted in the preservation of many teeth with minimum or without remaining coronal tooth structure. Endodontically treated teeth have been found to exhibit higher risk of fracture than vital teeth because of desiccation or premature loss of moisture supplied by the vital pulp, coronal destruction from dental caries, trauma, previous restorations and excessive removal of radicular dentin during endodontic treatment.[51] The restoration of endodontically treated teeth is important to ensure successful treatment outcome. Restoration provides protection and reinforcement of the tooth, and also prevents the passage of microorganisms and organic liquids into root canals. Endodontically treated teeth with extensive loss of coronal tooth structure are commonly restored with a post and core and a crown. [20]

The available post and core designs can be divided in to custom fabricated metal post and core and prefabricated post to which core is adapted.[26] The advantage of custom post and cores are that they can be used in teeth with very little remaining coronal tooth structure that have less fracture resistance. They have high rigidity and improve the fracture resistance of the endodontically treated teeth.[18,26] The disadvantages of cast post and core includes root fractures, corrosion, discoloration of gingiva and greyish appearance of all-ceramic crowns due to light reflection from the post and metal core.[18,26,37,49]

The use of prefabricated posts with core offer a number of advantages like biocompatibility, resistance to corrosion and fatigue, ease of removal and mechanical properties similar to the teeth.[26] The use of prefabricated post systems are preferred more as they are more practical, less expensive, eliminates casting procedure and in some situations less invasive than customized post and core system.[35]

Prefabricated posts can be classified as metallic and non-metallic posts. The metallic posts can be made of different materials like titanium and its alloys, stainless steel, platinum-gold-palladium, chromium containing alloys and brass.[26] The non-metallic posts are of various types like fibre posts including carbon fibre, glass fibre, quartz fibre, woven polyethylene fibre, glass fibre plus zirconia posts, ceramic and zirconia posts. But these prefabricated metallic and carbon fibre posts do not satisfy the esthetic requirements for anterior teeth. Increase in demand for esthetic restorations in dentistry have led to the implementation of tooth colored, metal free, translucent post and core systems.[17,50]

There is a wide range of availability of non-metallic esthetic posts such as fibre reinforced posts, ceramic posts and zirconia posts.[42] These posts have number of advantages over the metallic and carbon fibre posts. They have superior natural appearance than the metallic posts, good strength, resiliency that reduces fracture potential commonly seen with traditional metal posts, modulus of elasticity close to dentin and provide excellent biocompatibility.

They do not discolour teeth or gingival tissue. They are insoluble and impermeable to oral fluids and are corrosion resistant.[12,42]

Laboratory studies have investigated a number of physical properties such as rigidity, flexural strength, fracture resistance of the post and post/root relationship, retention testing of posts in the canal, core retention on the post, scanning electron microscopy of the post/root interface, microleakage, corrosion of metals with fibre posts, thermal stress, spectrophotometric analysis, cytotoxic properties and radiopacity of various post-core systems.[8]

Fracture resistance is of greater importance than retention because the post can be recemented if dislodged from tooth. However, if root fractures the tooth is invariably lost. [18] Different methods like photoelastic analysis, finite element method and mechanical studies with models (in vitro) have been suggested to determine the fracture resistance of post and core systems.[8] The direct application of photoelastic and finite element methods to the clinical situation is limited where as the laboratory model studies have been made to be clinically parallel since the structures modelled (i.e. bone, tooth, postcore and crown) are much more dynamic.[18]

In the literature, various factors have been evaluated with respect to fracture resistance of endodontically treated teeth that includes post length, post diameter, post material, post design, post adaptability, amount of remaining dentin, cement and method of cementation, core material, core design, biocompatibility of the post material, position of tooth, use of treated tooth and the load experienced by the restored teeth.[18]

Factors such as the amount of remaining tooth structure, ferrule effect of the crown, and magnitude and direction of functional loads probably have greater influence on survival rates of the post and core system.[36] Studies have concluded that fracture resistance of endodontically treated teeth were higher for teeth that had a ferrule of 2mm or more when compared to those without ferrule. Incorporating a ferrule into the design of the crown, embracing the circumference of the root, protects the root where maximum force occurs. Ferrule effect plays a key role in increasing the failure threshold of post treated teeth.[2, 18,19,30,38,45,48,51]

The correlation between post material and fracture of the endodontically treated teeth has been reported in literature.[8,18] The post material should have the same modulus of elasticity (rigidity) as root dentin to distribute the applied forces evenly along the length of post and root. The elastic modulus of fibre post is closer to that of dentin compared to that of metal posts. It was hypothesized that the dentin like rigidity would allow for reduction of stress concentrations between the dentin post interface and forces could be more evenly transferred to the root. Consequently the incidence of root fracture might decrease. On the other hand rigid metal post resisted lateral forces without distortion and resulting in stress transfer to the less rigid dentin causing potential root cracking and fracture. The fibre post flex under load and as a result distribute stresses between post and the dentin thereby decreasing the incidence of root fracture.[18,26]

Currently available fibre posts are carbon fibre post, glass fiber post, quartz fibre post and glass fibre plus zirconia post. The carbon fibre post is black in color and do not lend themselves to esthetic restorations with all ceramic restoration. This led to introduction of glass fibre and quartz fiber post which are transparent and more tooth colored. These new tooth colored posts can potentially improve esthetics of anterior teeth.[42]

A prefabricated zirconia post system has been introduced in 1989 to satisfy esthetic need presented by endodontically treated anterior teeth. This post is biocompatible, radiopaque and possesses high flexural strength, fracture toughness and provides optical properties similar to all ceramic crowns.[1]

The glass fibre posts and zirconia posts have gained popularity as esthetic posts because of their purported favourable biomechanical properties. Studies on fracture resistance of maxillary anterior teeth restored with esthetic posts are less in literature. Since there is a greater need for esthetic posts in the maxillary anterior region, the role of glass fibre and zirconia posts on fracture resistance needs to be evaluated.

Thus, the aim of the present in vitro study was to comparatively evaluate the fracture resistance and fracture patterns of endodontically treated anterior teeth restored with two different esthetic posts namely the glass fibre and zirconia posts.

The objectives of the study included the following:

1. To evaluate the fracture resistance of endodontically treated anterior teeth restored with glass fibre posts.(Group A)
2. To evaluate the fracture resistance of endodontically treated anterior teeth restored with zirconia posts. (Group B)
3. To compare the fracture resistance of endodontically treated anterior teeth restored with glass fibre and zirconia posts.(Group A and Group B)
4. To evaluate the fracture patterns of endodontically treated anterior teeth restored with glass fibre posts. (Group A)
5. To evaluate the fracture patterns of the endodontically treated anterior teeth restored with zirconia posts. (Group B)
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INTRODUCTION

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MATERIALS AND METHODS

The present in vitro study was conducted to comparatively evaluate the fracture resistance and fracture patterns of endodontically treated anterior teeth restored with two different esthetic posts.

The following materials were used in the study:

1. 20 recently extracted maxillary central incisors (Fig.1)
2. Saline (Nirlife, India) (Fig. 2)
3. Sodium hypochlorite 2.5% (Comet, Comodent Corporation, Mumbai, India) (Fig.3)
4. Gutta-percha points (Dentsply, Germany) (Fig.4)
5. Rootcanal sealer (Ah plus, Dentsply, Germany) (Fig.5)
6. Glassfibre posts (Exacto, Angelus, Brasil) (Fig. 6)
7. Zirconia posts (Icelight, Danville, California, U.S.A.) (Fig.7)
8. Silane (Angelus, Brasil) (Fig.8)
9. 37% phosphoric acid etching gel (Etch, D- tech, India) (Fig.9)
10. Dual cure Resin luting cement (Rely X U 100, 3M ESPE, Germany) (Fig.10)
11. Bonding agent (Adper single bond 2, 3M ESPE, Germany) (Fig.11)
12. Restorative light cure Composite (Z100 restorative,3M ESPE, Germany) (Fig.12)
13. Polyvinyl siloxane putty and light body impression material (Aquasil, Dentsply, Germany) (Fig.13)
14. Type-IV dental stone (Ultrarock, Kalabhai, Mumbai, India) (Fig 14)

15. Die hardener (Han Dae Chemicals, Germany) (Fig15 a)
16. Die spacer (Yeti Dental, Germany) (Fig15 b)
17. Die lubricant (Yeti Dental, Germany) (Fig 15 c)
18. Inlay wax (G C Corporation, Tokyo, Japan) (Fig.16)
19. Sprue wax (Bego, Germany) (Fig.17a)
20. Surfactant spray (Uni Coat, Delta, India) (Fig.17b)
21. Investment ring and crucible former (Sili Ring, Delta, India) (Fig.17c)
22. Phosphate bonded investment material (Bellasun, Bego, Germany) (Fig.17d)
23. Investment liquid (Begosol, Bego, Germany) (Fig.17e)
24. Separating discs 0.7 mm thickness (Dentorium, New York, USA) (Fig.17f)
25. Base metal alloy (Bellabond plus, Bego, Germany) (Fig.17g)
26. Aluminum oxide powder 110 microns (Aluminox 110, Delta , India) (Fig.18)
27. Metal trimming burs (Edenta, Switzerland) (Fig.19a)
28. Metal polishers (Edenta, Switzerland) (Fig.19b)
29. Universal polishing paste (Ivoclar Vivadent AG, Liechtenstein, Germany) (Fig.19c)
30. Type I Glass ionomer cement (G C Corporation, Tokyo, Japan) (Fig. 20)
31. Dipping wax (Duodip, Yeti Dental, Germany) (Fig.21)
32. Auto polymerizing clear acrylic resin (Cold cure, DPI- RR, India) (Fig.22)
33. Custom made metal mold (Fig. 23)
34. Custom made mounting jig (Fig. 24)

The following instruments and equipments used in this study:

1. Ultrasonic scaler (Pizeon, Switzerland) (Fig.25)
2. Airotor hand piece (Pana air, NSK, Japan) (Fig.26a)
3. Contra angle handpiece (NSK, Japan) (Fig.26b)
4. Barbed broach (Mani, India) (Fig.27)
5. Endodontic K Files (Mani, India) (Fig.28)
6. Flat end tapered diamond abrasive (Dia Burs, Mani, India) (Fig.29)
7. Torpedo diamond abrasive (Sunshine diamond, Germany) (Fig.30)
8. Peaso Reamer (Angelus, Brasil) (Fig.31)
9. Light cure unit (Confident, India) (Fig.32)
10. P.K. Thomas wax up instruments (Dispodent, India) (Fig.33)
11. Wax calliper (API, Germany) (Fig.34)
12. Vaccum mixer (Whipmix, U.S.A) (Fig.35)
13. Burnout furnace (Technico, Technico Laboratory Products Pvt. Ltd., Chennai, India) (Fig.36a)
14. Induction casting machine (Fornax GEU, Bego, Germany) (Fig.36b)
15. Sandblaster (Delta, India) (Fig.37)
16. Alloy Grinder (Demco, California, USA) (Fig.38)
17. Wax pot (Schuler Dental, Germany) (Fig.39)
18. Dental surveyor (Bego, Germany) (Fig.40)
19. Universal Testing Machine (Lloyd instruments, Farnham, U.K.) (Fig.41)

Description of universal testing machine:

In the present study, the fracture resistance of endodontically treated anterior teeth restored with two different esthetic posts were tested with the universal mechanical testing machine (Lloyd instruments, Farnham, U.K.). This machine rests on a table top. It consists of a lower chamber, upper chamber, a display board to display the amount of force needed and a computer. The upper member houses the hydraulic pressure machine. It also has the fixture to hold the vertical straight rod. The lower portion has a bench vice test specimen fixture to hold the test specimens. The whole unit is attached to a computer for recording and converting data as required. (Fig.41)

METHODOLOGY

The following methodology was adopted for preparation and for testing the samples.

1. Selection of teeth
2. Preparation of teeth for root canal treatment
3. Tooth preparation
4. Post space preparation
5. Cementation of posts
6. Core buildup
7. Preparation of Ni-Cr copings
8. Cementation of Ni-Cr copings
9. Embedding teeth with post core and copings in acrylic blocks
10. Simulation of periodontal ligament
11. Testing of samples for fracture resistance

1. **Selection of teeth:**

Twenty freshly extracted maxillary central incisors free of cracks, caries, fractures, and restorations were selected for the study (Fig 1). The external debris was removed with an ultrasonic scaler (Pizeon, Switzerland), and the teeth were stored in saline solution (Nirlife, India) until testing. The root lengths were measured from the cemento enamel junction of the proximal side to the root apex with a vernier caliper. A minimum of 14mm length was maintained for all the specimens. They were randomly divided into two groups A and B of 10 samples each.

2. Preparation of teeth for root canal treatment:

The anatomic crowns of all teeth were removed perpendicular to the long axis of the tooth, from the most incisal point to 2mm above the proximal cementoenamel junction (CEJ), with the use of a water cooled flat end tapered diamond abrasive (Diabur, Mani, India) to simulate grossly destroyed tooth (Fig.42). All twenty teeth were prepared in a similar manner. Access opening was done and the pulp extirpated with a barbed broach. All the 20 samples were endodontically treated using K-files (Fig.28) by a step-back procedure. The root space was sequentially prepared from size 15 to 50 size file. After intermittent rinsing with 2.5% sodium hypochlorite, (Fig.3) the endodontic treatment was completed (Fig.43) with lateral condensation of gutta-percha points (Gutta Percha Points; DENTSPLY) (Fig.4) and eugenol-free sealer (Ah plus; Dentsply, Germany) (Fig.5). The root canal fillings were allowed to set for 24 hrs.

3. **Tooth preparation:**

All the teeth were prepared with a torpedo diamond abrasive to establish a chamfer finish line at the level of cement enamel junction. The finish line was established circularly for standardization purpose and to get a crown ferrule of 2mm (Fig.44). Core ferrule of 0.5mm was obtained by preparing a contrabevel of 0.5mm at the coronal end of the tooth with a thin tapering diamond abrasive (Fig.29).

4. Postspace preparation:

The standardization followed for post space preparation in teeth are the post length of 13mm length to be prepared in the root.

Group A:

Tapered Glass fibre (Exacto, Angelus, Brasil) (Fig.6) were used for Group A samples. The length and diameter of the Glass fibre posts measured 17mm and 1.4mm at the broadest end respectively. Guttapercha was removed from the root canals with the peaso reamer (Fig.45) provided by manufacturer to create the space of 13mm from the coronal edge of tooth, leaving a minimum of 3mm of guttapercha apically. Post space preparation was checked by placing the post in the space created in the root. All the ten samples of group A were prepared for post space in a similar manner.

Group B:

Tapered Zirconia posts (Icelight, Danville, California, U.S.A) were used for Group B samples. The length and diameter of the zirconia dowel measure 17mm and 1.4mm at the broadest end respectively. Guttapercha was removed from the root canals with the peaso reamer provided by manufacturer to create the space of 13mm from the coronal edge of tooth, leaving a minimum of 3mm of guttapercha apically. Preparation of the post space was repeatedly checked by placing the post in the space created in the root. All the ten samples of Group B were prepared for post space in a similar manner (Fig.45).

5. Cementation of posts:

Group A: Glass fibre posts were luted to the post space of the 10 samples of Group A

Pretreatment of glass fibre post was done by application of silane (Angelus, Brasil) and air drying it (Fig.46). Self adhesive dual cure resin cement (Rely X U 100 , 3M ESPE, Germany) was applied in to the canal and thin layer of resin cement on the posts with help of periodontal probe. The posts were inserted in to the canal and the excess cement was removed (Fig.47). The coronal end of each dowel was positioned directly in contact with the tip of the light unit and was light polymerized for 40 seconds with a light cure (Confident, India) unit as per the manufacturer recommendation.

Group B: Zirconia posts were luted to the post space of the 10 samples of Group B

Pretreatment of zirconia posts was not done as it was recommended. Self adhesive dual cure resin cement was coated on the walls of the post space. A thin layer of resin cement is applied on the posts with help of periodontal probe. The posts were then inserted into the canal and the excess cement was removed (Fig.48). The coronal end of each dowel was positioned directly in contact with the tip of the light unit and was light polymerized for 40 seconds with a light cure unit as per manufacturers' recommendation.

6. Core buildup:

Dentin was prepared by etching the tooth surface with 37% phosphoric acid (D-tech, India) (Fig.8) for 15 seconds. Etchant was rinsed off with water for 10 seconds. Once etching was done the tooth surface was dried with compressed air. 2-3 coats of bonding agent (Adper single bond 2, 3M ESPE, Germany) (Fig.11) was applied on the etched tooth surface. It was then thinned out by air blowing gently and light cured for 10 seconds as per the manufacturers' recommendations. A light-polymerizing composite core (Z 100, Restorative, 3M ESPE, Germany) was built on the sample in an incremental manner. The height of the core was maintained to 4.0 mm from the coronal edge of the tooth and finished with an ultrafine diamond abrasive (Fig.49). Core was built for all the samples of Group A and B in a similar manner.

7. Preparation of Ni-Cr copings:

a) Pattern fabrication**:**

i) Making impression of samples:

The impression of the teeth restored with post and core were made using one stage putty wash impression technique. The light body consistency Poly vinyl siloxane (Aquasil, Dentsply, Germany) (Fig.13) was syringed to the sample surface when the putty consistency Polyvinyl siloxane (Aquasil, Dentsply, Germany) (Fig.13) was mixed by another operator and loaded on to the tray. The loaded tray was impressed on the tooth and the tooth and the impression was made (Fig.50). A total of twenty impressions were made, for the samples of Group A and B in a similar manner.

ii) Fabrication of die:

Type-IV dental stone (Ultrarock, Kalabhai, Mumbai, India) (Fig.14) was mixed with water as per manufacturer's recommended ratio of 3:1 and poured into the sample impression. After the die was allowed to set for 1 hour and then removed from the impression. The set die (Fig.48) was then trimmed apically using a pear shaped bur to demarcate the finish line. All the dies were prepared in the same manner.

iii) Wax pattern fabrication:

A single coat of die hardener (Handae Chemicals, Germany) (Fig.15a) was applied over the finish line area. This was followed by the application of a single layer of die spacer (Yeti Dental Products, Germany) (Fig.15b) to provide relief over the entire die, stopping short of the finish line area by 2 mm(Fig.52). Once this dried satisfactorily the die was coated thoroughly with die lubricant (Yeti Dental Products, Germany) (Fig.15c) and left to allow the lubricant to soak in. Excess lubricant was then removed using a gentle stream of compressed air. The initial wax coping was then formed by dipping the die into molten wax and the excess wax was removed using a P.K.T. no.4. This was followed by the addition of cervical wax using P.K.T. no. 1 to complete the coping. A notch was then carved on the lingual surface 3 mm below the incisal edge (Fig.53) using P.K.T. no. 4. Care was taken to maintain a thickness of 1 mm all around, which was verified using a wax calliper (API, Germany) (Fig.54).

b) Spruing the patterns:

The wax pattern was sprued with preformed wax sprue (Bego, Germany) of 2.5 mm diameter. The wax sprue was attached to the incisal edge of the pattern and a reservoir was placed on the sprue 1.5 mm away from the pattern. The pattern was directly sprued to the crucible former (Fig.55a) of the ring less casting system (Sili Ring, Delta, India) (Fig.17c). All the patterns were sprued in an identical manner.

c) Investing the patterns:

All patterns were invested individually using graphite free, phosphate bonded investment material (Bellasun, Bego, Germany) (Fig.17d). A 6 mm distance was provided between the patterns and top of the ring. All patterns were sprayed with surfactant spray (Aurofilm, Bego, Germany) (Fig.17b), to aid in better wetting of the investment material. As per the manufacturer's recommendation, 160 gm of phosphate bonded investment was mixed with 38ml of investment liquid which was prepared by mixing 30 ml of colloidal silica and 8 ml of distilled water in the ratio of 75:25 respectively. The investment powder and liquid were first hand mixed with a spatula until the entire material was wetted thoroughly followed by a vacuum mixing for 30 seconds. Once the investment was mixed the entire pattern was painted with a thin layer of investment using a small paint brush. The sili ring was positioned on the crucible former and the remainder of investment was vibrated slowly in to the ring (Fig.55b). The invested patterns were allowed to bench set for 20 minutes, and the sili ring removed.

d) Pattern elimination:

All the invested patterns were placed in a burn-out furnace after setting of the investment (Technico, Technico laboratory products Pvt Ltd Chennai, India) (Fig.36a) for pattern elimination. Investments with the patterns were left in the burnout furnace for a period of three hours. During the first hour, the temperature was raised from room temperature to 380°C; in the second hour, the temperature was raised to 900°C and during the last hour the temperature was sustained at 900°C to accomplish complete burnout of the pattern without any residue. The investment mold was initially placed in the furnace such that the crucible end was in contact with the floor of the furnace for the escape of molten material. The investment mold was reversed later near the end of the burnout cycle with the sprue hole facing upward to enable escape of the entrapped gases and also to allow oxygen contact to ensure complete burnout of the pattern.

e) Casting:

Casting was accomplished with Ni-Cr alloy (Bellabond plus, Bego, Germany) (Fig17g) melted in an induction casting machine (Fornax GEU, Bego, Germany) (Fig.36b). The casting procedure was performed quickly to prevent heat loss resulting in the thermal contraction of the mold. The Ni-Cr alloy was heated sufficiently till the alloy ingot turned to molten state and the crucible was released. The centrifugal force ensured the complete flow of the molten metal into the mold space.

f) Divesting and finishing the metal substructure:

Following casting the hot casting was cooled to room temperature. A knife was used to trim the investment at the button end of the ring. It was then broken apart and the remaining investment was slowly removed (Fig.56a). Adherent investment was removed from the casting by air abrading with 110µm alumina (Delta, INDIA) (Fig.18) at 80 psi pressure in a sand blasting machine (Delta, India) (Fig.56b). Sprue was cut using 0.7mm thin separating discs (Dentorium, New York, USA) (Fig.17f). The casting was inspected under magnification for casting defects. Casting with irregularities in the internal margin, distorted surfaces were discarded. External surfaces were relieved of all nodules with a round carbide bur and steam cleaned. Thickness of the metal substructure was measured using an Iwanson's gauge to ensure that the required thickness of 1mm of metal substructure was achieved (Fig.57). This procedure was repeated for all twenty specimens. All the metal copings were finished and polished using metal trimming burs (Edenta, Switzerland) (Fig.19a), metal polishers (Edenta, Switzerland), silicon carbide rubber points, white and grey (Dentsply, India) (Fig.19b) and finally by Universal polishing paste (Ivoclar Vivadent AG, Liechtenstein, Germany) (Fig.19c).

8. Cementation of Ni-Cr copings:

Type I glass ionomer powder and liquid (G C Corporation, Japan) (Fig.20) was taken in the mixing pad in a ratio based on manufacturers' recommendation. Both powder and liquid were mixed with folding technique and used to lute the copings on the tooth specimens (Fig.58). Excess material was removed and copings were allowed to set.

9. Embedding teeth with post core and copings in acrylic blocks:

All the teeth with post core and coping (Fig.59) were embedded in acrylic block for testing purpose, the root surface of the teeth were dipped in the dipping wax till the level of cement enamel junction to get a even thicknesses of 0.3mm. This was done to simulate space for the periodontal ligament (Fig.60). A custom made silicone mold was fabricated. The silicone mold was fabricated with polyvinyl siloxane impression material with an internal mold block size is 25mm height and 15mm width. Sample was placed perpendicular to the floor with the help of surveyor in to the mold space (Fig.61). Autopolymerizing clear acrylic resin was poured in to the mold and the tooth was positioned till the level of wax near cementoenamel junction. The resin was allowed to polymerize. This procedure was done for all the samples to obtain individual resin blocks for all the test samples.

10. Simulation of periodontal ligament:

The teeth in the resin block were labelled. After the polymerization of acrylic resin, the teeth were removed from the resin block and the wax eliminated. After removal of wax light body was syringed into the resin block and the tooth specimen placed into it (Fig.62). This was done to simulate the periodontal ligament around the tooth. Once the polymerization was complete, the excess was removed. This was done for all the test samples. The twenty samples of teeth with post and core, metal copings, light body for simulation of periodontal ligament, embedded in resin block were ready for testing (Fig.63, 64).

11. Testing of samples for fracture resistance:

The samples were tested for fracture resistance under static load by using Universal testing machine. To simulate the load in the anterior teeth, the force was applied at 45^0 to the long axis of the tooth. A metal jig was fabricated to position the resin block so that it would create an angle of 45^0 to the floor. The metal jig with the resin block was mounted in the lower member and the upper member had the vertical straight rod. A shear force was applied to the metal coping at a cross head speed of 1mm / min until fracture occurred (Fig.65). The maximum fracture loads were recorded in Newton. The fracture pattern was also recorded (Fig.66, 67).

DISCUSSION

The restoration of endodontically treated teeth, although practiced for many years, remains a major concern in dentistry.[18] The main factors that make endodontically treated teeth more prone to failures are thin walled, weakened roots predisposing them to root fractures and reduced retentive surfaces resulting in high stress levels in the cements.[48]

Posts play a significant role in reducing the fracture of endodontically treated teeth which are weaker due to desiccation or premature loss of moisture supplied by a vital pulp.[51] They strengthen the weakened endodontically treated teeth against intraoral forces by distributing torquing forces within the radicular dentin to supporting tissues along their roots.

Various post designs like cast post and core, prefabricated metallic posts and prefabricated non-metallic posts are being used in dentistry in an attempt to retain the core and to improve the fracture resistance of the endodontically treated teeth.

Custom cast post and cores have superior physical properties. However, they produce a greyish discolouration of gingival and translucent all ceramic crowns.[17] Also they are very rigid with high flexural strength predisposing the tooth to root fracture.

Prefabricated posts like stainless steel, brass, titanium, fibre, ceramic and zirconia posts are being increasingly used due to their advantages like biocompatibility, resistance to corrosion and fatigue, ease of removal and mechanical properties similar to the teeth.[26] The use of prefabricated post systems are preferred more as they are more practical, less expensive, eliminates casting procedure and in some situations less invasive than customized post and core system.[35] A disadvantage of metallic prefabricated posts are they do not satisfy the esthetic requirements for anterior teeth.

Glass fibre posts were introduced in 1992, they are composed of unidirectional glass fibre embedded in a resin matrix that strengthen the dowels without compromising the modulus of elasticity.

Zirconia has been used for root canal post in 1989 and they have good optical & biological properties. These posts are made from fine grained tetragonal zirconium polycrystals and have high fracture toughness, high flexural strength and excellent resistance to corrosion.[1]

These non metallic posts have number of advantages over the metallic posts. They have superior natural appearance than the metallic posts, good strength resiliency that reduces fracture potential commonly seen with traditional metal posts, modulus of elasticity close to dentin and provide excellent biocompatibility. Use of these prefabricated posts also eliminates the extra procedure of pattern fabrication for casting as in a custom post. They do not discolour teeth or gingival tissue. They are insoluble and impermeable to oral fluids and are corrosion resistant.[12,42] Reviews show that they have been unanimously suggested for preventing coronal microleakage.[52]

Various factors related to fracture resistance of endodontically treated teeth have been evaluated with respect to post length, post diameter, post material, post design, post adaptability, amount of remaining dentin, cement used and the method of cementation, core material, core design, biocompatibility of the post material, position of tooth, use of endodontically treated teeth and the load experienced by the restored teeth.[18]

Considering the need for esthetic posts for anterior teeth, glass fibre posts and zirconia posts were tested in the study.

In order to stimulate clinical conditions, a mechanical model study was done wherein extracted natural maxillary incisors were endodontically treated and restored with glass fibre and zirconia posts. Composite core was built and base metal alloy copings were cemented onto the prepared teeth. Periodontal ligament was simulated using light body and the samples were then treated for fracture resistance.

This type of model studies have shown to be advantageous over other methods like photoelastic analysis and finite element method. Different methods like photoelastic analysis, finite element method and mechanical studies with models (in-vitro) have been suggested to determine the fracture resistance of post and core systems.[8] The direct application of photoelastic and finite element methods to the clinical situation is limited where as the laboratory model studies have been made to be clinically parallel since the structures modelled (i.e. bone, tooth, post core and crown) are much more dynamic.[18]

Retention of posts can be achieved by using luting agents like zinc phosphate, zinc polycarboxylate, glass ionomer and resin cements. It has been reported that the cement layer provides a buffer zone that contributes to uniform stress distribution between the post and the canal.[7,18] Mendoza et al showed that resin cements give additional resistance to fracture compared to brittle, non bonding zinc phosphate cement. They bond well to the glass fibre posts and zirconia posts. All the posts in the current study were luted with dual cure resin cements after appropriate preparation of the post space and the post to ensure proper bonding with the root. It has been demonstrated that resin-based cements have greater retention than do conventional cements, such as zinc phosphate. [46]

The choice of core material also plays a role in fracture resistance. The ability of a post to distribute stress can be affected by the core material. The use of composite, glass-ionomer or amalgam core have been described in literature.[18]The modulus of elasticity of the core material affects the distribution of the stress. Composite resin core has been reported to help in distribution of stresses to the surface underneath the core, thus creating less cervical stress. Also bonding composite cores to the fibre posts has improved the retention and resistance of the cores. Composite cores have been shown to have higher fracture strength than ceramic cores.[52] Considering esthetics offered by the composite core and its good physical properties, composite core was used in this study. Teixeira ECN et al [46] has done a study he reported the load to fracture was 45.1N for glass fibre post with no core and crown.

Tooth preparation was done to establish a 2 mm crown ferrule and 0.5 mm core ferrule. Studies have concluded that fracture resistance of endodontically treated teeth were higher for teeth that had a ferrule of 2mm or more when compared to those without ferrule. Incorporating a ferrule into the design of the crown, embracing the circumference of the root, protects the root where maximum force occurs. Ferrule effect plays a key role factor in failure threshold for post treated teeth.[2,18,19,30,38,45,48,51]

Ni-Cr copings were fabricated and cemented with Type I glass ionomer cement to simulate clinical situations. The coping was designed to have a notch in the palatal aspect to provide a positive stop for the vertical rod of the universal testing machine. It was positioned 3mm cervical to the incisal edge of the coping to simulate normal occlusal contacts between the maxillary and mandibular anterior teeth.

Teeth mounted in resin have limited resiliency. The use of autopolymerizing resin liberates heat which can affect the dentin. It can lead to deceased moisture content, crazing and weakening of the sample, which will indirectly affect the fracture resistance value. In order to simulate periodontal ligament for incorporating the resilience factor, polyvinyl siloxane was used in this study.[18]

A custom made jig was fabricated to position the acrylic blocks in a 45˚ angulation to the floor. This was to establish a 135˚ angle with the vertical rod of the testing machine. This was done to simulate normal relationship between the anterior teeth, since clinically, the anterior teeth are placed at an angle to the occlusal plane; the forces are therefore not directed along their long axes.[18]

The results obtained in the current study evaluating the fracture resistance of teeth restored with glass fibre and zirconia posts were tabulated and subjected to statistical analysis. The mean maximum load for fracture resistance of samples with glass fibre post was 798.2N. Study done by Akkayan B et al [2] has reported a highest fracture resistance of 998.4N for maxillary canine with glass fibre posts. Kianoosh et al [47] has reported mean failure loads of 1015.2N for mandibular premolars with glass fibre posts. Giovani AR et al[20] has reported mean value of strength for compressive load of 31.7N in maxillary canines, the absence of periodontal simulation, incomplete coverage of roots with acrylic resin and shorter posts could have resulted in lower values. Comparison with this study emphasizes the need for periodontal simulation for distributing forces. McLaren JD et al[34] evaluated the mean ultimate failure load of different post systems. He found out that premolar with glass fibre post and composite core exhibited a mean ultimate failure load of 166.7N when tested without a crown.

The mean maximum load value obtained for zirconia posts obtained in the study was 840.6N. Study done by Akkayan B et al [2] has reported a highest fracture resistance of 954.2N for maxillary canine with zirconia posts. Fracture loads reported by Oblak C et al[37] for zirconia posts have ranged from 385 to 993N, based on the diameter of the post. Kern et al have published preliminary, encouraging results on the use of zirconia posts for the esthetic restoration of nonvital teeth. Heydecke G et al has reported mean values of

521N for maxillary central incisors with zirconia posts restored with composite posts.

In the literature, the maximum incisal forces of anterior teeth varied, but the amount was almost always below 200N, which is much lower than the the failure loads of glass fibre posts (798.2N) and zirconia posts (840.6N) used in this study.[40] Therefore, it may be suggested that anterior teeth with a 2mm ferrule, restored with glass fibre and zirconia posts, would resist normal occlusal forces. However, this study did not consider the influence of parafunctional habits such as bruxism.

The sites of fracture for samples with glass fibre post and zirconia posts samples were also recorded. All the samples exhibited a predominant tendency to fracture at the cervical third of crown or the middle third of root. Glass fibre posts exhibited an increased tendency to fracture at the cervical third of crown, whereas zirconia posts exhibited an increased tendency to fracture at the middle third of root. The glass fibre posts samples also exhibited fracture at the middle third of crown and apical third of root whereas zirconia post samples had no fracture in these sites.

Giovani AR et al[20] has reported high percentage of fractures at the cervical third of root with glass fibre posts while McLaren JD et al[34] has reported no root fractures when tested only with cores. The presence of base metal alloy copings and ferrule in this study might be additional factors that can be accounted for high fracture resistance and fracture of the tooth at the maximum load.

Fractures in the cervical third of crown has been reported to be repairable by Heydecke G et al[22] while fractures below that have been termed as catastrophic by Heydecke G et al.[22] The high elastic modulus of zirconia posts could be the cause of greater percentage of root fractures.[52] Considering the high percentage of root fractures in zirconia post samples in comparison with glass fibre posts there is a greater need for further evaluation of other factors like flexural strength and modulus of elasticity of the post to reduce the incidence of root fractures for maxillary central incisor. Further studies need to be conducted with esthetic all ceramic crowns instead of metal crowns to simulate the esthetic restorations as in a clinical situation. The role of post length, remaining dentin and the root configuration in reducing root fractures needs to be assessed for these esthetic posts.

The present in-vitro study has several limitations testing the samples in static loading; it does not directly replicate forces in the oral cavity with regard to size of load and nature of load. Most pulpless teeth in vivo probably fail as a result of fatigue failure, so resistance to static loads is not the only issue of interest. The specimens were not thermal cycled and ageing was not done, which has the effect of degradation of the luting agent and may possibly influence the outcome. Only maxillary central incisors were used, these results can only be applied to that group of teeth. Furthermore, cement pressure was not standardized, as only finger pressure was used. It is also important that clinician consider the various types of materials available for post systems, as well as their mechanical properties. Future research is necessary to clarify the effects of different lengths of new post systems on the resistance to fracture.

RESULTS

The present in- vitro study was conducted to comparatively evaluate the fracture resistance and fracture patterns of endodontically treated anterior teeth restored with two different esthetic posts, namely glass fibre and zirconia posts.

A total of twenty recently extracted maxillary central incisors were endodontically treated. Tooth preparations were done maintaining 2mm ferrule length from proximal cementoenamel junction. Post space preparation was done for all 20 samples. Ten samples received glass fibre posts and were considered as Group A. The remaining ten samples received zirconia posts and were considered as Group B. The luting of the posts in the both the Group A and B was done with self adhesive resin cement. Core build was done for all the test samples with light curable composite. Nickel chromium cast copings were fabricated to the test samples and luted with Type I glass ionomer cement. The test samples were embedded in acrylic block wherein periodontal ligament simulation was done. These samples were placed in position at a 45^0 angulation to the loading cell of the testing apparatus. The test samples were than subjected to static loading in universal testing machine until they fractured, and maximum load in Newton were recorded. The results obtained from the study were tabulated and subjected to statistical analysis. The fracture patterns with respect to various locations of fracture of endodontically treated anterior teeth were tabulated and compared for Group A and Group B samples.

- Table I shows basic values, mean and standard deviation of maximum load for fracture resistance of Group A samples.
- Table II shows basic values, mean and standard deviation of maximum load for fracture resistance of Group B samples.
- Table III shows the Comparison between mean values of maximum load for fracture resistance of Group A and B samples using Independent student's T-test.
- Table IV shows the fracture patterns with respect to locations of fractures of Group A samples.
- Table V shows the fracture patterns with respect to locations of fractures of Group B samples.
- Table VI shows the comparison of fracture patterns with respect to locations of fractures of Group A and Group B samples.
- Graph I shows the basic values of maximum load for fracture resistance of Group A samples.
- Graph II shows the basic values of maximum load for fracture resistance of Group B samples.
- Graph III shows the comparison of mean values of maximum load for fracture resistance of Group A and B samples
- Graph IV shows the comparison of fracture patterns with respect to locations of fractures of Group A and B samples.

Table I: Basic values, mean and standard deviation of maximum load for fracture resistance of Group A samples

Sample No.	Maximum load (N)
1	588
2	584
3	572
4	568
5	652
6	1090
7	900
8	1015
9	993
10	1020
Mean	798.20
Standard deviation +/- 222.424	

Table II: **Basic values, mean and standard deviation of maximum load for fracture resistance of Group B samples**

Sample No.	Maximum load (N)
1	678
2	690
3	755
4	686
5	702
6	820
7	1035
8	850
9	1100
10	1090
Mean	840.60
Standard deviation +/- 172.353	

Table III: Comparison between mean values of maximum load for fracture resistance of Group A and B using Independent student's T-Test

GROUP	Number of samples	Mean	Std. Deviation	P - value
A	10	798.20	+/-222.424	0.639
B	10	840.60	+/-172.353	

P value > 0.05; insignificant

Inference – On statistical comparison of the mean fracture resistance values of Groups A and B, P value > 0.05, denoting no statistical significance between the two Groups.

Table IV: Fracture patterns with respect to locations of fractures of Group A samples.

Sample No.	Fracture pattern
1	middle third of root
2	middle third of root
3	cervical third of crown
4	cervical third of crown
5	cervical third of crown
6	cervical third of crown
7	cervical third of crown
8	apical third of root
9	middle third of root
10	middle third of crown

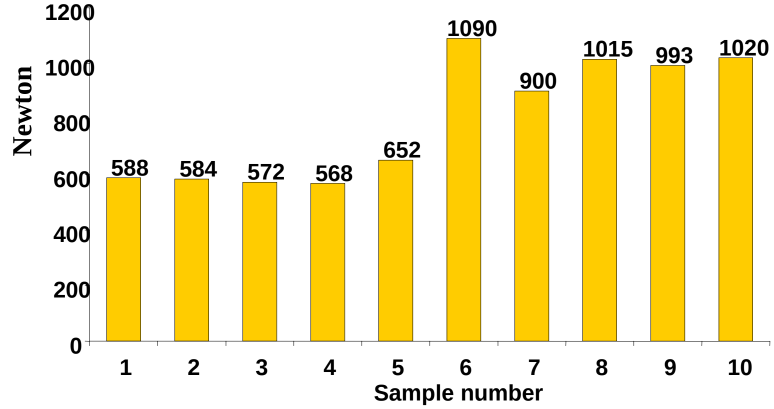
Table V: Fracture patterns with respect to locations of fractures of Group B samples.

Sample No.	Fracture pattern
1	middle third of root
2	middle third of root
3	cervical third of crown
4	middle third of root
5	middle third of root
6	cervical third of crown
7	cervical third of crown
8	cervical third of crown
9	middle third of root
10	middle third of root

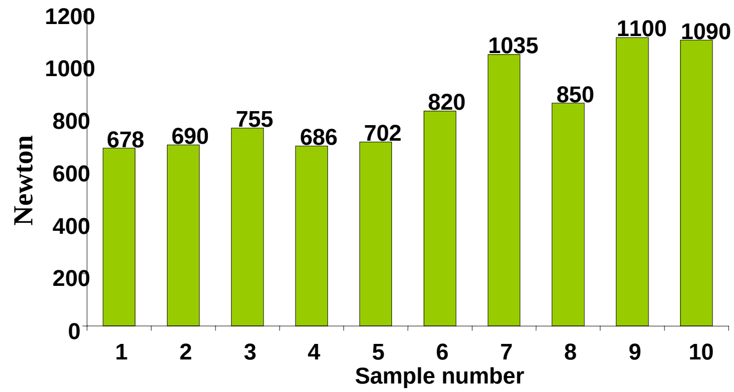
Table VI: Comparison of fracture patterns with respect to locations of fractures of Group A and Group B samples

Groups	No. of samples (n)	Middle third of crown	Cervical third of crown	Middle third of root	Apical third of root
A	10	1	5	3	1
B	10	0	4	6	0

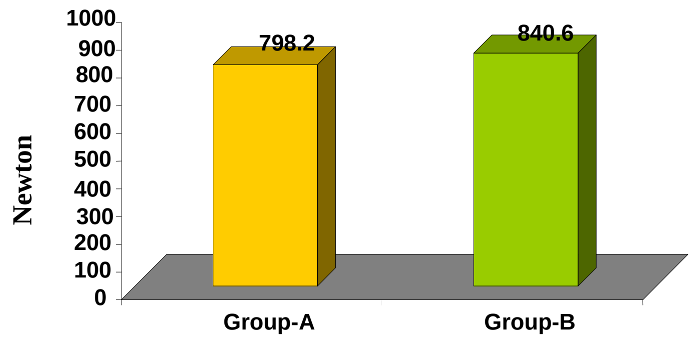
Graph I: Basic values of maximum load for fracture resistance of Group A samples



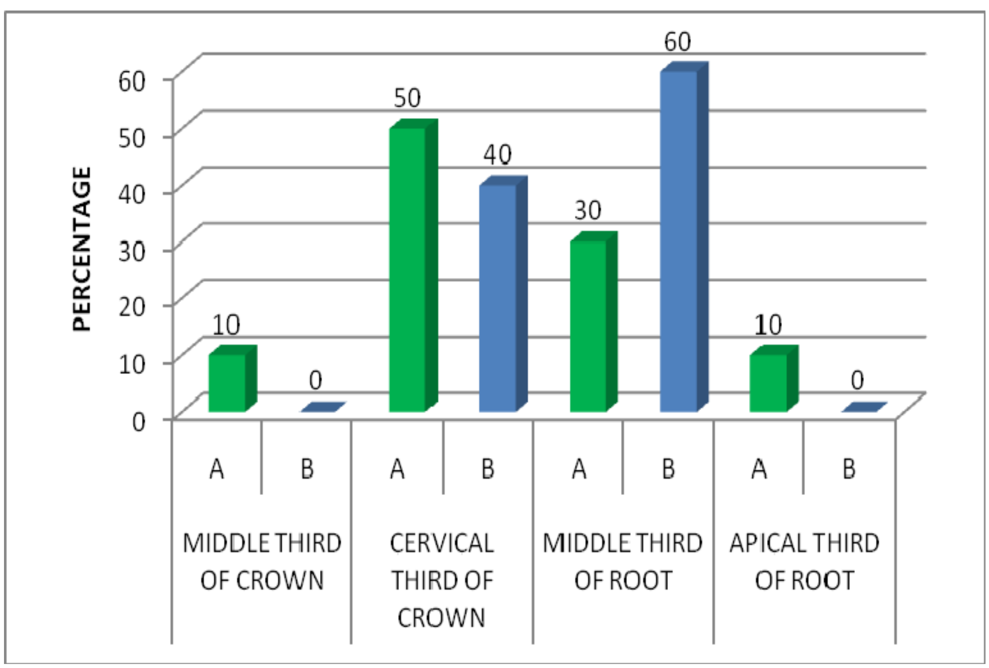
Graph II: Basic values of maximum load for fracture resistance of Group B samples



Graph III : Comparison of mean values of maximum load for fracture resistance of Group A and B samples.



Graph IV: Comparison of fracture patterns with respect to location of fracture of Group A and B samples.



CONCLUSION

The following conclusions were drawn from this present in vitro study, which was conducted to comparatively evaluate the fracture resistance and fracture patterns of endodontically treated anterior teeth restored with two different esthetic posts:

1. The mean maximum load for the fracture resistance of endodontically treated anterior teeth with glass fibre posts was found to be 798.20 Newtons.
2. The mean maximum load for the fracture resistance of endodontically treated anterior teeth with zirconia posts was found to be 840.60 Newtons.
3. On comparison, the mean maximum load value for fracture resistance for test samples with zirconia posts was higher than that for the test samples with glass fibre posts. However, the difference in mean values was found to be statistically insignificant. (p value >0.05)
4. The fracture patterns with respect to locations of fractures for Group A samples were as follows: Middle third of crown – 1 tooth (10%), cervical third of crown -5 teeth (50%), middle third of root -3 teeth (30%) and apical third of root -1 tooth (10%)
5. The fracture patterns with respect to locations of fractures for Group B samples were as follows: cervical third of crown -4 teeth (40%) and middle third of root -6 teeth 60%).

6. On comparison, Group A samples exhibited 10% of fracture in middle third of crown while Group B samples exhibited no fracture in middle third of crown. Group A samples exhibited 50% of fracture in cervical third of crown while Group B samples exhibited 40% of fracture in cervical third of crown. Group A samples exhibited 30% of fracture in middle third of root while Group B samples exhibited (60%) of fracture in middle third of root. Group A samples exhibited 10% of fracture in apical third of root while Group B samples exhibited no fracture in apical third of root. Overall, samples with glass fibre posts exhibited greater crown fracture (60%) while samples with zirconia posts exhibited greater root fracture (60%).

SUMMARY

The present in vitro study was conducted to comparatively evaluate the fracture resistance and fracture patterns of endodontically treated anterior teeth restored with two different esthetic posts, namely glass fibre posts and zirconia posts.

A total of twenty freshly extracted, maxillary central incisors were used in this study. They were randomly divided into two test Groups A and B of ten samples each. All the samples were endodontically treated. Tooth preparation was done to obtain a 2mm ferrule for the crown and post space preparation was done uniformly for all the samples and the teeth. Group A test samples were restored with glass fibre posts and Group B with zirconia posts. All the samples were then subjected to core build up with light cure composite material. Nickel chromium cast copings were fabricated and cemented to the prepared teeth with post-core. All the samples were embedded in acrylic resin block with the periodontal ligament simulation and subjected to static loading in universal testing machine. The maximum load at which fractures occurred for all the test samples were recorded and tabulated.

Statistical analysis was made with independent student's T test and P value less than 0.05 was considered significant. Samples with zirconia posts exhibited greater fracture resistance than those with glass fibre posts. However, the differences in the mean values between the two Groups were not

statistically significant. This study indicates that both the esthetic posts, namely glass fibre and zirconia posts exhibited similar fracture resistance statistically.

The fracture patterns with respect to locations of fractures were also tabulated for Group A and Group B samples. Visual inspection of the fracture patterns of the endodontically treated anterior teeth restored with glass fibre and zirconia posts have revealed that use of zirconia posts exhibited 60% of the root fracture while glass fibre posts exhibited 60% of crown fractures.

The choice of an appropriate restoration of endodontically treated teeth is guided by strength and esthetics. Cast metal post and core foundation have a long history of successful use due to the superior physical properties. However, esthetics properties of these materials are limited when used to support the all-ceramic restorations, in the prosthetic rehabilitation of maxillary anterior region. The Prefabricated posts made of tooth coloured material such as glass fibre or zirconia have become popular because they increase the transmission of light within the roots and overlying tissues.

In this in vitro study, the post and core foundations with glass fibre and zirconia posts exhibited higher values of fracture resistance (798.20 N, 840.60 N) than the maximum physiological forces of 200N acting on the teeth in the oral cavity.[40] Therefore, it may be suggested that endodontically treated anterior teeth restored with these posts would resist normal occlusal forces.

Hence, these posts can be used as an alternative to cast post core or prefabricated metallic posts in the maxillary anterior region.

Further studies to examine fracture mechanics, as well as long-term clinical investigations are needed to evaluate the performance of glass fibre and zirconia posts.

BIBLIOGRAPHY

1. **Akgungor G, Sen D, Aydin M.** Influence of different surface treatments on the short term bond strength and durability between a zirconia post and a composite resin core material. J Prosthet Dent 2008; 99(5): 388-399.
2. **Akkayan B.** An in vitro study evaluating the effect of ferrule length on fracture resistance of endodontically treated teeth restored with fiber-reinforced and zirconia dowel systems J Prosthet Dent 2004; 92(2): 155-62.
3. **Al-Hazaimeh N, Gutteridge DL.** An in vitro study into the effect of the ferrule preparation on the fracture resistance of crowned teeth incorporating prefabricated post and composite core restorations. Int Endodon J 2001; 34: 40-45.
4. **Aquilino SA, Caplan DJ.** Relationship between crown placement and the survival of endodontically, treated teeth. J Prosthet Dent 2002; 87(3): 256-63.
5. **Asmussen E, Peutzfeldt A, Sahafi A.** Finite element analysis of stresses in endodontically treated, dowel-restored teeth. J Prosthet Dent 2005; 94(4): 321-9.
6. **Assif D, Oren E, Marshak BL, Aviv I.** Photoelastic analysis of stress transfer by endodontically treated teeth to the supporting structure using different restorative techniques. J Prosthet Dent 1989; 61(5): 535-43.

7. **Balbosh A, Kern M.** Effect of surface treatment on retention of glass-fiber endodontic posts. J Prosthet Dent 2006; 95(3): 218-23.

8. **Bateman G, Ricketts DNJ, Saunders WP.** Fibre-based post systems: a review. British Dental J 2003; 195(1): 43-8.

9. **Bex RT, Parker MW, Judkins JT, Pelleu GB.** Effect of dentinal bonded resin post-core preparations on resistance to vertical root fracture. J Prosthet Dent 1992; 67(6): 768-72.

10. **Burgess J.O, Summitt J.B, Robbins J.W.** The resistance to tensile, compression, and torsional forces provided by four post system. J Prosthet Dent 1992; 68(6): 892-903.

11. **Burns AD, Krause WR, Douglas HB, Burns DR.** Stress distribution surrounding endodontic posts. J Prosthet Dent 1990; 64(4): 412-8.

12. **Cohen BI, Musikant L, Deutsch AS.** Comparison of retentive properties of four post systems. J Prosthet Dent 1992; 68(6): 264-268.

13. **Cooney JP, Caputo AA, Trabet KC.** Retention and stress distribution of tapered-end endodontic posts. J Prosthet Dent 1986; 55(5): 540-6.

14. **Creugers NHJ, Mentink AGM, Fokkinga WA, Kreulen CM.** 5-Year Follow-up of a Prospective Clinical Study on Various Types of Core Restorations. Int J Prosthodont 2005; 18(1): 34-39.

15. **Deutsch AS, Cavallari J, Musikant BL, Silverstein L, Lepley J, Petroni G.** Root fracture and the design of prefabricated posts J Prosthet Dent 1985; 53(5); 637-640.

16. **Deutsch AS, Musikant BL, Cavallari J, Bernardi S.** Retentive properties of a new post and core system. J Prosthet Dent 1985; 53(1); 12-14.

17. **Dilmener FT, Sipahi C, Dalkiz M.** Resistance of three new esthetic post-and-core systems to compressive loading. J Prosthet Dent 2006; 95(2): 130-6.

18. **Fernandes AS, Dessai GS.** Factors affecting the fracture resistance of post- core reconstructed teeth: A review. Int J Prosthodont 2001; 14(4): 355-363.

19. **Gegauff AG:** Effect of crown lengthening and ferrule placement on static load failure of cemented cast post-cores and crowns. J Prosthet Dent 2000; 84(2): 169-79.

20. **Giovani AR, Vansan LP, Neto MDS, Paulino SM.** In vitro fracture resistance of glass-fiber and cast metal posts with different lengths. J Prosthet Dent 2009; 101(3): 183-188.

21. **Hatzikyriakos AH, Reisis GI, Tsingos N.** A 3-year postoperative clinical evaluation of posts and cores beneath existing crowns. J Prosthet Dent 1992; 67(4): 454-8.

22. **Heydecke G, Butz F, Hussein A, Strub JR.** Fracture strength after dynamic loading of endodontically treated teeth restored with different post-and-core systems J Prosthet Dent 2002; 87(4): 438-45.

23. **Heydecke G, Peters MC.** The restoration of endodontically treated single-rooted teeth with cast or direct posts and cores: A systematic review. J Prosthet Dent 2002; 87(4): 382-6.

24. **Ho MH, Lee S, Chen HH, Lee MC.** Three-dimensional finite element analysis of the effects of posts on stress distribution in dentin. J Prosthet Dent 1994: 72(4): 367-72.

25. **Hoag EP, Dwyer TG.** A comparative evaluation of three post and core techniques .J Prosthet Dent 1982; 47(2): 177-181.

26. **Insua AM, Da Silva L, Rilo B, Santana U.** Comparison of the fracture resistances of pulpless teeth restored with a cast post and core or carbon-fiber post with a composite core. J Prosthet Dent 1998; 80(5): 527-32.

27. **Jeong SM, Ludwig K, Kern M.** Investigation of the fracture resistance of three types of zirconia posts in all-ceramic post and core restorations. Int J Prosthodont 2002; 15(2): 154-8.

28. **Johnson JK, Sakumura JS.** Dowel form and tensile force. J Prosthet Dent 1978; 40(6): 645-9.

29. **Kalkan M, Usumez A, Ozturk AN, Belli S, Eskitascioglu G.** Bond strength between root dentin and three glass-fiber post systems. J Prosthet Dent 2006; 96(1): 41-6.

30. **Loney RW, Kotowicz WE, McDowell GC.** Three-dimensional photoelastic stress analysis of the ferrule effect in cast post and cores. J Prosthet Dent 1990; 63(5): 506-12.

31. **Maniatopoulos C, Pilliar RM, Smith DC.** Evaluation of shear strength at the cement-endodontic post interface. J Prothet Dent 1988;59(6):660-9.

32. **Mannocci F, Bertelli E, Sherriff M, Watson TF, Ford TRP.** Three-year clinical comparison of survival of endodontically treated teeth restored with either full cast coverage or with direct composite restoration. J Prosthet Dent 2002; 88(3): 297-301.

33. **Mannocci F, Ferrari M, Watson TF.** Intermittent loading of teeth restored using quartz fiber, carbon-quartz fiber, zirconium dioxide ceramic root canal posts. J Adhesive Dent 1999; 1(2): 153-8.

34. **Mc Laren JD, Mc Laren CI, Yaman P, Bin-Shuwaish MS, Dennison JD, Mc Donald NJ.** The effect of post type and length on the fracture resistance of endodontically treated teeth. J Prosthet Dent 2009; 101(3): 174-182.

35. **Newman MP, Yaman P, Dennison J, Rafter M, Billy E.** Fracture resistance of endodontically treated teeth restored with composite posts. J Prosthet Dent 2003; 89(4): 360-7.

36. **O'Keefe KL, Powers JM:** Adhesion of resin composite core materials to dentin. Int J Prosthodont 2001;14(5):451-456.

37. **Oblak C, Jevnikar P, Kosmac T, Funduk N, Marion L.** Fracture resistance and reliability of new zirconia posts. J Prosthet Dent 2004; 91(4): 342-8.

38. **Oliveira JA, Pereira JR, Valle AL, Zogheib LV.** Fracture resistance of endodontically treated teeth with different heights of crown ferrule

restored with prefabricated carbon fiber post and composite resin core by intermittent loading**.** Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2008; 106: e52-e57.

39. **Piovesan EM, Demarco FF, Cenci MS, Pereira-Cenci T.** Survival rates of endodontically treated teeth restored with fiber-reinforced custom posts and cores: A 97-Month Study. Int J Prosthodont 2007; 20(6): 633-639.

40. **Qing H, Zhu Z, Chao Y, Zhang W.** In vitro evaluation of the fracture resistance of anterior endodontically treated teeth restored with glass fibre and zircon post. J Prosthet Dent 2007; 97(2): 93-8.

41. **Sahafi A, Peutzfeldt A, Asmussen E, Gotfredsen K.** Retention and failure morphology of prefabricated posts. Int J Prosthodont 2004; 17(3): 307–312.

42. **Shetty T, Bhat GS, Shetty P.** Aesthetic postmaterials. Journal of Indian Prosthodontic Society. 2005; 5(3): 122-125.

43. **Sirimai S, Riis DN, Morgano SM.** An in vitro study of the fracture resistance and the incidence of vertical root fracture of pulpless teeth restored with six post-and-core systems. J Prosthet Dent 1999; 81(3): 262-9.

44. **Stahl GJ, O' Neal RB.** The composite resin dowel and core. J Prosthet Dent 1975; 33(6): 642-8.

45. **Tan PLB, Aquilino SA, Gratton DG, Stanford CM, Tan SC, Johnson WT, Dawson D.** In vitro fracture resistance of endodontically treated central incisors with varying ferrule heights and configurations. J Prosthet Dent 2005; 93(4): 331-6.

46. **Teixeira ECN, Teixeira FB, Piasick JR, Thompson JY.** An in vitro assessment of prefabricated fiber post systems.JADA 2006;137:1006-12.

47. **Torabi K, Fattahi F.** Fracture resistance of endodontically treated teeth restored by different FRC posts: An in vitro study. Indian J Dent Res 2009; 20(3): 282-7.

48. **Torbjörner A, Fransson B.** A literature review on the prosthetic treatment of structurally compromised teeth. Int J Prosthodont 2004; 17(3): 369-76.

49. **Vichi A, Ferrari M, Davidson CL.** Influence of ceramic and cement thickness on the masking of various types of opaque posts. J Prosthet Dent 2000; 83(4): 412-7.

50. **Xible AA, Tavarez RRJ, Araujo CRP, Bonachela WC.** Effect of silica coating and silanization on flexural and composite-resin bond strengths of zirconia posts: An in vitro study. J Prosthet Dent 2006; 95(3): 224-9.

51. **Zhi-Yue L, Yu-Xing Z.** Effects of post-core design and ferrule on fracture resistance of endodontically treated maxillary central incisors. J Prosthet Dent 2003; 89(4): 368-73.

52. **Zeynep, Iseri, Kazazoglu.** Zirconia ceramic post systems: a literature review and case report. Dent Mater J 2010; 29(3): 233-45.